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ABSTRACT

This pilot study examines the influence of a diagnostic and post-test format as a continuous diagnostic tool to help one cohort of elementary preservice teachers address their mathematics content area deficiencies in a proactive way. Fifty-four percent of the preservice teachers in the cohort were persons of color, and 96 percent were female. The goal of the course was to empower these preservice teachers with the knowledge and skills necessary to enroll in the mathematics methods course. Along with diagnostic and post-test data, the instructors used interviews and journals to address students' questions and concerns about the course. The findings show improvement in all of the mathematics subtopics that were tested. However, several areas remained problematic, especially word problems, area, and perimeter. In addition, the journals and interviews revealed a high level of mathematics anxiety for this cohort of preservice teachers. The diagnostic and post-test format may have increased mathematics anxiety for some participants and impeded their learning. However, courses like the one presented in this paper are needed to help prospective teachers, who are of any gender or race, to improve their conceptual understanding of mathematics. (Contains 25 references.) (SM)

**EMPOWERING ALL ELEMENTARY PRESERVICE TEACHERS TO TEACH
CHILDREN MATHEMATICS**

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Running Head: Empowering All Preservice Teachers

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ABSTRACT

This pilot study examines the influence of a diagnostic and post-test format as a continuous diagnostic tool to help one cohort of elementary preservice teachers address their mathematics content area deficiencies in a proactive way. Fifty-four percent of the preservice teachers in the cohort were persons of color, and 96% were female. The goal of the course was to empower these preservice teachers with the knowledge and skills necessary to enroll in the mathematics methods course. Along with diagnostic and post-test data, the instructors used interviews and journals to address students' questions and concerns about the course. The findings show improvement in all of the mathematics subtopics that were tested. However, several areas remained problematic, especially word problems, area, and perimeter. In addition, the journals and interviews revealed a high level of mathematics anxiety for this cohort of preservice teachers. The diagnostic and post-test format may have increased mathematics anxiety for some participants and impeded their learning. However, courses like the one presented in this paper are needed to help prospective teachers, who are of any gender or race, to improve their conceptual understanding of mathematics.

EMPOWERING ALL ELEMENTARY PRESERVICE TEACHERS TO TEACH CHILDREN MATHEMATICS

INTRODUCTION

While the *Standards* have been the impetus for mathematics reform in the 1990s (NCTM, 1989 & 1991), one problem that mathematics educators continue to face is addressing the ability of elementary preservice teachers to effectively teach children mathematics. Many prospective elementary teachers lack the skills needed to be good teachers of mathematics (Manouchehri, 1998). Unless preservice teachers' mathematical content knowledge improves, future elementary teachers are likely to shy away from teaching challenging and exciting mathematics to another generation of children. We know that teachers who have poor attitudes about the subject are more likely to pass those feelings on to their students (Quinn, 1997). Strengthening the skills and concepts of preservice teachers in mathematics should improve their instruction. Teacher educators must attend to preservice teachers' broad and contextual mathematics knowledge in order to strengthen their ability to teach the subject. (Manouchehri, 1998). Pedagogical content knowledge, which involves the "how" of teaching the specific content, must also be addressed (Shulman, 1987). Thus, improving teachers' content and pedagogical content knowledge is the first step in empowering them to teach mathematics well.

Mathematics, often viewed as a white male domain, has been taught as an exact science (Buerk, 1985; Campbell, 1995). However, the majority of elementary majors are female and different ways of teaching mathematical competence are needed (Buerk, 1985). Teacher educators must do more to prepare all elementary teachers to be proficient in mathematics and to be better teachers of mathematics. Teacher educators can begin this process by assessing their own instruction as well as assessing the knowledge of preservice teachers.

The purpose of this paper is to share the results of a pilot study in which two teacher educators examined the mathematical content, pedagogical needs, and beliefs of one cohort of undergraduate students admitted to the teacher education program at a northeastern university. These preservice teachers were enrolled in a prerequisite course for mathematics methods. Our goal was to empower these preservice teachers to gain the knowledge necessary to continue in the teacher education program and to realize the importance of being a good mathematics teacher. But how teachers deliver the mathematics content or curriculum depends on their perceptions and images of the mathematics they teach (Brown & Cooney, 1982). In this pilot study, we wanted to learn what those perceptions and images were as well as to help these preservice elementary teachers learn the mathematics they needed in order to teach children effectively.

REVIEW OF THE LITERATURE

Two bodies of literature inform this pilot study: 1) preservice teachers' mathematical content knowledge, and 2) perceptions and attitudes about teaching mathematics. A brief review of the literature linking these bodies of research to current knowledge in the field and describing their contributions to this study are presented below and followed by the theoretical framework.

Preservice Teachers' Mathematical Content Knowledge

The literature is replete with examples of preservice and inservice elementary teachers' limited knowledge in mathematics (Ball, 1990; Ball, 1990a; Quinn, 1997; Stoddart, Connell, Stoffleett, and Peck, 1993). One topic in mathematics that gives preservice teachers difficulty is fractions. Ball (1990) found that elementary teacher candidates were able to calculate one and three-fourths divided by one half ($1 \frac{3}{4} \div \frac{1}{2}$), but only 30% were able to correctly select from a

list of choices in a story problem to represent $1 \frac{3}{4} \div \frac{1}{2}$. Furthermore, in an interview setting, none of the elementary candidates were able to generate an example of $1 \frac{3}{4} \div \frac{1}{2}$.

Quinn (1997) found that even after a mathematics methods course that showed significant gains in mathematical content knowledge, preservice elementary teachers could only answer 17 out of 24 questions correctly on a sixth-grade level test. The preservice teachers did particularly poor on questions related to fractions, multiplication of fractions, long division, geometry, circumference of a circle, and probability. The percentage of participants answering questions on each of these topics correctly was 33.3%, 48.2%, 29.6%, 14.8%, 48.2%, and 29.6%, respectively. A statistics question was answered correctly by only 51.9% of the preservice teachers. Stoddart, Connell, Stoffleett, and Peck (1993) found that 90% of the preservice teachers in their study lacked "any real understanding of the concept of rational number" (p. 238).

These findings reveal that there are serious shortcomings in preservice teachers' ability to do certain kinds of mathematics problems. Unfortunately, these knowledge deficits may find their way into the elementary classroom. Fractions are generally taught in depth when students reach the upper elementary grades. If elementary preservice teachers have difficulty understanding fraction concepts, they may have trouble teaching them to children. This paper is not intended to place blame on preservice teachers but to emphasize the importance of the role mathematics educators in improving, diagnosing, and addressing possible deficits in preservice teachers' mathematical content knowledge.

Teacher Beliefs

Foss and Kleinsasser (1996) found that preservice teachers' conceptions of mathematics often revolved around computational aspects or the profusion of mathematics in activities like making change. Preservice teachers rarely discussed links to creativity or reasoning.

Mathematics is, for some, simply numbers, arithmetic operations, or computational skill. Further, these teacher candidates believed that students must possess innate knowledge or a particular type of mind in order to understand mathematics. However, this idea reinforces the belief that some students "just can't do math."

Civil (1992) found that elementary education students in a preservice mathematics methods class were concerned more about classroom management and student motivation, rather than about how to teach mathematics. They believed their role as math teachers would be to tell students what to do, that is how to set up a problem. Teaching skills was a priority for these prospective teachers. Pressure for teachers to cover the content and conform to the school's teaching culture may contribute to these actions.

Prospective teachers seemed driven by a need to conform to "school ways," a sense of how things are supposed to work in school mathematics. This sense of school was largely influenced by the teachers' own experiences in K-12. "School ways" embody an efficiency model that emphasizes getting answers fast and covering a great deal of material. Preservice teachers were also sensitive to issues of frustration, confusion, and putting children off. In this study, Civil (1992) noted that if the teachers found an idea difficult, they assumed that it would be "confusing" for children.

The aforementioned studies inform our work as teacher educators in significant ways. First, it is important to understand our own work and how our instruction of mathematics content and mathematics methods courses influence students' content knowledge and beliefs. Second, it is important to learn what preservice teachers' experiences, content knowledge, and beliefs are in order to meet their conceptual and pedagogical needs.

Beliefs about teaching are often well established by the time a student matriculates in college (Pajares, 1992 as cited in Hart, 2002). However, pedagogical practices that support constructivist teaching may be nurtured by engaging prospective teachers in constructivist experiences in learning and teaching mathematics (Hart, 2002). "Teacher beliefs drive their teaching of mathematics" (Hart, 2000, p. 4) and thus can be a source of qualitative data to assess how well teacher education programs function to change traditional beliefs to a more constructivist perspective. Assessment of teachers' beliefs, knowledge, and practice is needed and can be obtained from examining teacher reflections (Valli, 1992 as cited in Watson, 2001).

THEORETICAL FRAMEWORK

A Nation at Risk: The Imperative for Educational Reform (1983) informed us that students in the U.S. were losing ground internationally in the areas of mathematics and science. As a result, theoretical work in mathematics and mathematics education has fundamentally changed (NCTM, 2000). Rather than understanding mathematics as purely abstract and separate from human endeavor, cognitive science places human minds back into mathematics to construct what is called a mind-based mathematics (Lakoff & Nunez, 1997). While Lakoff and Nunez (1997) claim that their understanding of mathematics is neither Platonist nor constructivist, their conceptual understanding is grounded in sensorimotor functioning, which is akin to Piaget's philosophy. Piaget understands the "individual [as] a self regulating autonomous organism making sense and meaning from sensorimotor, social, and textual experiences" (Lerman, 1996, p. 147). Piaget's work is grounded in the preconstructivist revolution that occurred around 1970, which grew into our present understanding of constructivism that individuals must construct their own meaning of new experiences (Lerman, 1996; Steffe & Kieren, 1994). The theoretical framework used in this pilot study is constructivism. Preservice teachers must be able to

construct their own understanding of mathematical concepts in order to teach children effectively and appreciate the variety of children's thinking in problem solving. Prior to describing our study, a brief overview of our teacher education program is presented below.

OUR TEACHER EDUCATION PROGRAM

Early childhood and elementary education majors must have 60 hours of general requirements and a total of 128 semester hours to graduate with a B.S. in Education. Six semester hours are required in mathematics and three semester hours in a mathematics methods course. In addition to the mathematics methods, students were also required to take science methods, social studies methods, art, and literacy and early childhood courses.

From 1998 – 2000 preservice teachers were required to pass the Mathematics Teacher Readiness Exam (MTRE) or take Mathematics Skills and Concepts (MTH ED 140) course prior to enrollment in mathematics methods. The MTRE and the MTH ED 140 course were developed within the Department of Curriculum and Instruction because of a CETP grant that was received from the National Science Foundation to support college reform in the teaching of mathematics and science education courses in the College of Education. We were neither PIs nor Co-PIs on this grant but were responsible for teaching the MTH ED 140 course if students failed the test. The MTRE was developed by senior science and mathematics educators and was not tested for reliability and validity. This pilot study is about a cohort of diverse students who did not pass the MTRE and were enrolled in our MTH ED 140 course and has implications for college administrators and teacher educators.

THE STUDY

Research Questions

The purpose of this pilot study was to examine the impact of a prerequisite mathematics course on the content knowledge and beliefs of preservice elementary teachers and to use student feedback to improve our instruction as mathematics educators. The goals of the course were to address the students' mathematical deficits while preserving their dignity, identify their strengths and weaknesses, and to address areas of need in a proactive way. The research questions are as follows:

- (1) How did the course format (diagnostic and post-tests) influence diverse preservice teachers' learning in course?
- (2) How did the course address preservice teachers' self-reported weaknesses in mathematics?
- (3) How did the course impact preservice teachers' beliefs about how to teach mathematics?

Methodology

Participants

The participants included all of the students ($n=24$) who were enrolled in the prerequisite mathematics education course (MTH ED 140) during the spring of 2000. The objective of the course was to improve the skills and concepts of undergraduate early childhood and elementary education majors prior to taking mathematics methods. The cohort was 37.5% Black (African and African-American), 12.5% Asian, 4% Hispanic, and 46% White. These descriptive statistics were different from the demographics of students enrolled in the college, which was 17.9% African American, 3.7% Asian, 3.4% Hispanic, 0.4% Native American, 67.7% White, and 6.4%

Other. The class was also predominantly female since 23 females and 1 male were enrolled in the course. The average age of the students was 22 years old.

Measures

The data sources that were used to answer the research questions included students' exams, interviews, and journal responses. Descriptive statistics were used to analyze the exams since this was not a controlled study. We chose the diagnostic and post-test format because we believed that it would provide us and the students with the most direct feedback about our teaching and keep the students informed of their progress in the course. A qualitative analysis of finding underlying themes and patterns was used to analyze the journals and the interview transcripts. The journals were open-ended, but the preservice teachers were encouraged to write down their feelings about course or the content and to ask questions if they had any.

Procedures

We began teaching the course Mathematical Skills and Concepts (MTH ED 140) in 1998. Each of us had taught the course once prior to co-teaching the course in the spring of 2000, which met three days a week (MWF) for 50 minutes. Prior to teaching the course, we gave the students a different version of the MTRE (see Appendix). There were three different forms of the test, which allowed students to retake it and test out of the course, if they did not pass it the first time. Twenty out of 40 questions needed to be answered correctly in order to pass. We learned that some students had not taken the exam but simply enrolled in the course because they believed they would have failed the test. As a result of the MTRE exam, three students tested out of the course and enrolled in the mathematics methods course.

Based on the recommendations of the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) and the *Professional Standards for Teaching Mathematics* (NCTM,

1991, we created the course syllabus. As a result of our analysis, the content would focus primarily on four broad areas: 1) numbers and operations, 2) probability and statistics, 3) measurement, and geometry, and 4) patterns and functions. However, we decided to focus on both content and pedagogy in order to model for the teachers how they would teach the concepts. Such a format also allowed us to use a variety of teaching strategies, such as lecture, group work, use of manipulatives, and classroom discussion. The format also provided an opportunity for students to revisit basic concepts (i.e. fractions) in a professional manner and not just in a remedial way. In order to assess student learning throughout the course, we gave diagnostic and post-tests on each of the content areas listed above. Students were allowed to use calculators on the exams, and the final exam was cumulative. In order to improve our communication with the students, we required them to submit a journal on a weekly basis and to participate in a mid-semester interview. Written feedback was provided in the students' journals, and verbal feedback was given during the oral interviews.

Results

Two data sources were used to obtain qualitative data: student interviews and journals. Each of these data sources are described in detail below:

Analysis of the Student Interviews

The interviews were conducted halfway through the course. Thus, the preservice teachers had some experience with the course material before the interview was conducted. Over a one-week period, we each interviewed 12 students for fifteen minutes using a protocol. The protocol contained the following questions:

- 1) What are some of your weaknesses in mathematics?
- 2) What do you consider to be your strengths in mathematics to be?

3) Do you think the diagnostic and post-test format is helpful to you in this course?

4) How do you feel about the course in general?

As a result of the preservice teachers' interviews, they perceived themselves to be weak in the following areas: word problems, geometry, measurement, probability, and statistics. Most students considered their strengths to be in the use of formulas and proofs, fractions, and algebra. The students' comments reveal that they based their assessment of their strengths and weaknesses on how well they did on the diagnostic and post-tests. Ninety percent of the students thought the diagnostic and post-test format was helpful. However, the diagnostic tests were a source of student anxiety:

One weakness was doing the first page of the diagnostic test.

My weaknesses are the numbers I missed on the test.

The diagnostic test does matter; it's a test, and I still get anxious.

Other information that was learned from the student interviews included how the students felt about the course in general. Some of the comments were:

I felt stupid being in the class, but I am appreciating it more.

The course is teaching me how to teach kids in a fun way.

It's a good refresher.

I like the class a lot; I'll be able to understand and teach math better.

Analysis of the Journals

Figure 1 lists some of the most prevalent student comments, which were categorized as teacher feedback. Figure 2 outlines a few students' comments related to beliefs. Other journal comments reveal students' attitudes and anxiety about mathematics (see Figure 3). Analysis of all the comments reveal that affective words such as "like," "enjoy," and "hate" were used 40 times. The next most prevalent word used was "exam" or "test" and "grade." These words reveal that student attitudes and anxiety dominated their journal writing.

To get an in depth view of teacher knowledge, beliefs, and attitudes, examples from the journals of three preservice teachers are presented below. All of these preservice teachers were female, one was Kenyan (Student A), one was Asian (Student B), and one was White (Student C). Entries in each student's journal are shown by date.

Teacher Knowledge

1. Student A

- 02.04.00 The different methods of solving fraction problems such as the butterfly method are easy to apply and understand. Overall, so far the course is bearable, and I like math because now I can understand why instead of only following rules.
- 02.07.00 So far, the adding and subtracting of fractions is clear. But I have a bit of unclarity with multiplication and division.

$$(-2)(1/2) = -4 \text{ Why?}$$

$$(-2/1)(1/2) = -2/2 = -1$$

$$3/4 \div 2 = 3/4 * 1/2 = 3/8$$

$$7 \frac{1}{4} \div 2 = 29/4 * 1/2 = 29/8 = 3 \frac{5}{8}$$

The flip method is clear and easy in division.

The ratio problem we did in class was a bit unclear, especially the first problem regarding Mr. Smith. The answer was understood 6:1 or 60:10. But the question itself was unclear to me. Maybe because English is my second language. I tend to like straightforward queries rather than queries telling a story.

- 02.16.00 I tend to confuse simultaneous events.
A dice 1/6 chance of getting one side. Two dice rolled at the same time I thought was 1/12 (which I was told was wrong).

2. Student B

- 01.13.00 I always hated fractions just because sometimes it takes forever to get the answers, and also because it gets confusing. However, the teacher brought out the concept of the butterfly method. It was a quick and simple technique. I was very excited to learn about the butterfly method.

- 02.11.00 The problem with the sweater being \$40.00 and we take 20% off and later take another 10% off threw me off. I think it's because I hate shopping. I do like going during the sale season but I don't do the math unless it's 50% or 25% off. If you give me another number, I don't bother! Can you show me how we got the answer for that question?

3. Student C

- 02.02.00 I get confused with decimals and fractions. I forgot that $\frac{8}{10}$ is the same as .8 or $\frac{125}{1000}$ is the same as .125. Also a mixed decimal is the same as a mixed fraction (2.50 is $2\frac{1}{2}$). In high school nobody really taught me how to understand the meaning of math. We just did the problems. Percents mean hundredths. Every time I have a percent, I really have a fraction: 50% equal $\frac{50}{100}$. They are the same.
- 03.01.00 I never learned about the mode and median when I was in high school or any school. I thought these words were about a graph. The mode was the low point, and the median was the same. But it really means mode, the most number in group, and median, the middle number in the group. I did not understand the theoretical probability. Is it the number of outcomes in the event divided by the number of possible outcomes?
- 03.20.00 Learning the measurements is the hardest thing for me to do in math because there are so many different measurements.

Teacher Beliefs/Attitudes.

1. Student A

- 03.27.00 The activities we've been doing in class with shapes of different sorts and measurement using blocks are really good for children. The approach is fun as well as educational.

2. Student B

- 03.24.00 I am really thinking to order the blocks that we use in class because they become handy. I really enjoy working with them, and they also make a clear picture of the concept functions.

3. Student C

- 02.20.00 I like how the class is running because we are doing problems and taking it step by step.

Analysis of the Diagnostic and Post-Tests

The diagnostic and post-test scores provided us with some important information about our students. Four diagnostic and post-tests were given over the duration of the course. The first topic was numbers and number sense. This included operations on whole numbers, fractions, decimals, percentages, ratio/proportion, estimation, and ordering. The second topic was probability and statistics. This included reading charts, stem and leaf and box and whisker plots, comparing and summarizing data, predicting outcomes, and computing simple probabilities. The post-test was a take home alternative assessment while the diagnostic was more traditional. The third topic was geometry and measurement. This included perimeter, area, volume, geometric terms, and combining and converting measures. The fourth test was on patterns and functions. The diagnostic included using the coordinate plane and the point/slope form of a line, operations on integers, order of operations, evaluating expressions, solving equations and word problems, and producing a graph to describe a function over time. The post-test included using the coordinate plane and the point/slope form of a line, evaluating expressions, and solving equations and word problems.

Discussion

The results of this study revealed some startling findings for us. First, we wanted a method to keep the preservice teachers' informed of their progress. Our intention was to empower the diverse group of students that we worked with by diagnosing their strengths and weaknesses, informing them of their progress on a regular basis, and addressing their knowledge deficits. Both the journals and diagnostic and post-tests were tools that we thought would help us accomplish this goal.

Moreover, the preservice teachers were very willing to share their knowledge deficits and questions with us in the journals. We learned which strategies and activities were helpful and which ones were not. Students A and B, who are mentioned above, stated that the butterfly method was helpful to them in understanding fractions. There were many positive comments about the "butterfly" method. The "butterfly" method uses the algorithm of cross-multiplication to compare fractions. However, loops are drawn around the cross products to simulate the wings of a butterfly. When the multiplication is done, the answers are written at the top of each wing. The student can then compare the two whole numbers to determine which fraction is greater and which one is less.

We responded to each of the student's questions by making comments in their journals using their questions to guide our classroom instruction. We used pattern blocks to help the teachers understand operations with fractions. They were able to model addition and subtraction of halves, thirds, and sixths. Cuisenaire rods were used to model multiplication and division of fractions. We were able to address student errors such as $(-2)(1/2) = -4$ by using different colored rods for negative and positive numbers. Misconceptions like believing the probability of rolling two dice is $1/12$ were confronted by having students roll the dice and record the outcome. We then analyzed the results using a table and the students discovered for themselves that there were 36 possibilities. Therefore, the correct denominator for the probability of rolling two dice is 36. Moreover, they learned that 7 had the highest probability ($6/36$ or $1/6$) of being rolled because there were six ways to get a 7 when two dice were rolled (i.e. $3 + 4$, $4 + 3$, $2 + 5$, $5 + 2$, $1 + 6$, and $6 + 1$). The journals also inform us that the students appreciated the course better when we focused less on their weaknesses and more on helping them to teach children math. Finally, it

appears from the student journals that some teacher attitudes changed for the better while others did not (see Figure 2).

The diagnostic and post-test format allowed us to learn what the students knew and teach them the skills they needed. The mean on the tests improved from 52% to 84% on test one, 56% to 78% on test three, and 39% to 59% on test four. Results from test two were incompatible because of the different format — in class versus take-home. Therefore, no table of comparison is presented. Student performance on each of the sub-skills improved on these tests (7% to 44%) in general. Tables 1 and 2 show the results by race on test one. These data were disaggregated because they showed some interesting results when students of color and white students were compared on the diagnostic and post-test. Students of color actually had higher scores on whole number operations than white students at the outset. These data support the claim that students of color receive a great deal more instruction on performing basic skills rather than understanding concepts (Ladson-Billings, 1997). While students of color scored lower on every other sub-skill on the diagnostic, they were about the same in their knowledge of fractions and ratio-proportions on the post-test. This implies that strategies like the butterfly method and the use of manipulatives were very helpful in general but particularly helpful to students of color. Students of color outperformed white students on post-test in percents. Their deeper understanding of fractions and decimals may have helped to improve this sub-skill. Oddly their strongest area became the weakest. Students of color had the least gain in whole number operations when they were actually higher than white students were at the outset. This finding may be attributable to the fact that students were told to focus on improving the skills that they did not know. As shown in Table 2, all of these preservice teachers were pretty weak in mathematics. They averaged around 50% accuracy on the diagnostic. Post-test scores were not significantly different

by race either. Therefore, the strategies we used were equally effective for all preservice teachers, regardless of race. Clearly, further research is needed to understand and explain these data.

In general, the greatest sub-skill gain was on post-test three (see Table 3), which shows a 100% gain for volume. It should be noted that the post-test had only one problem related to volume. Though the gain looks impressive, it may not indicate full understanding of volume for the students in this class. Surprisingly, the preservice teachers did not improve substantially in their knowledge of area and perimeter. Moreover, students had the most difficulty with the point/slope formula, writing equations, and word problems on test four (see Table 4). These data were not disaggregated by race because of the scores were low to begin with and differences were unremarkable.

How did the course address the teachers' self-reported weaknesses in mathematics? As noted above, the teachers reported their weakest areas in mathematics to be word problems, geometry, measurement, and probability and statistics. The quantitative data show that word problems (whole number operations) improved from 52.2% to 71.0%. However, scores only rose from 32.6% to 50.0% for algebraic word problems. Recognition of geometry terms increased from 72.1% to 84.4%. While the ability to work problems with area and perimeter increased from 0% to 43.5% and 8.7% to 52.2%, respectively, the preservice teachers still did not have good understanding of these concepts. The teachers' ability to work problems dealing with measurement increased from 68.1% to 79.0% for addition and subtraction and from 65.9% to 84.1% for multiplication and division. No data are available for probability and statistics due to the incompatibility of the diagnostic and post-test. Preservice teachers made some of the strongest gains in their weakest areas, which were area, perimeter, and algebraic word problems.

However, our findings were that their mathematical knowledge was still inadequate in these areas after the course.

While we designed the course to address students' weaknesses and build upon their strengths, the qualitative data seem to show that revealing students' shortcomings increased their anxiety throughout the course. As the preservice teachers became more aware of their knowledge deficits, their level of anxiety increased. This is evidenced by the fact that many anxiety types of statements were made in student journals directly after taking a diagnostic test. As a result, students became more fearful of making mistakes and more grade conscious. Students' confidence increased when they did well on the tests. Some students wanted us to provide a more traditional than constructivist teaching style because they believed it would help them to do well on the tests. The use of manipulatives helped them to realize the necessity of being able to teach concepts to children, but their immediate need to pass the course, take mathematics methods, and to qualify for student teaching overshadowed these anxiety-reducing features of the course (Harper & Danne, 1998). Thus, the diagnostic and post-test format did not help us to achieve all of our goals.

CONCLUSION

This pilot study is important because colleges of education and teacher education programs have to become more accountable for the teachers they produce. Many administrators in large urban school districts have been concerned about the quality of the teachers they hire. Many are not proficient in mathematics and thus unable to effectively teach the students. We attempted to address this problem by requiring an additional course for students who were weak in mathematics. However, we found that this population of preservice teachers had a very high level of math anxiety. In order to empower a group such as this to become more proficient in

mathematics, teacher educators must first deal with the mathematics anxiety. Focusing on test performance was clearly not the way to do this. Focusing on skills while teaching weaker teachers how to effectively teach children (a methodological approach rather than a skill deficit approach) was received more favorably. The work of Tooke and Lindstrom (1998) support this finding. Thus, having a "pre-methods" course rather than a basic skills and concepts course may have accomplished the same purpose while maintaining course integrity and decreasing math anxiety. Additional research in this area is warranted. We intend to conduct a more detailed formal study in our methods courses to measure math anxiety before and after our teaching by using the Mathematics Anxiety Rating Scale (MARS). The more formal study would also include using the Mathematics Beliefs Instrument (MBI) to determine how preservice teachers beliefs about mathematics teaching change as a result of our instruction.

In Pennsylvania and other states, educational reforms have taken the shape of increasing admission standards to teacher education programs. Colleges of education are required to seek stronger students to begin with. Instead of a 2.5 GPA, students are now required to have a 3.0 GPA and pass the Praxis I before they are admitted into our teacher education program. While raising standards is commendable, such policies have the potential to weed out minority candidates who may have difficulty passing standardized tests. Thus, the pool of elementary teachers, which consists predominantly of white females, may become even more homogeneous.

Courses like the one described in this pilot study helped to maintain diverse students in our teacher education program. Being able to ask questions either verbally in class or non-verbally in journals improved these preservice teachers mathematical knowledge and increased their level of comfort to a certain degree. The MTRE is no longer given as a prerequisite to mathematics methods. Student must now pass the Praxis I, but MTH ED 140 is no longer taught.

Remedies such as *LearningPlus* (Educational Testing Service, 1993) is being used as a tutorial to help students pass the Praxis I. Pretests in reading, writing, and mathematics are given, and a sophisticated learning management system tracks students' performance and generates reports. *LearningPlus* provides students with 35 hours of instruction with scaffolding or supports to carry out a task. Then slowly the support is removed, giving students more responsibility for their own learning (ETS, 1993). At the present time, students must either pass the Praxis I or drop out of the program. The significance of this study is that there used to be a course to usher preservice teachers into methods rather than losing them through Praxis. Teachers of diverse backgrounds are needed to be role models for all children, especially children of color. We cannot empower teachers who are no longer in the program. Our charge as teacher educators is to empower all preservice teachers who want to teach children mathematics well.

LIMITATIONS

One noticeable limitation of this study was the instructors' choice not to use the Mathematics Teacher Readiness Exam (MTRE) as a final post-test. At the outset the instructors knew that many students had a very negative reaction to the MTRE. Some students felt they did not have time to prepare for it and that the test was unduly difficult. Many students had a sense of failure related to the MTRE and felt vulnerable because of that experience. The instructors' did not want to add any negative feelings to the experience of testing or the course, so the MTRE was not used a second time.

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Table 1: Breakdown of Sub-skills for Test 1 (20 items) by Race

	Number Sense	Whole Number Operations	Fractions	Decimals	Percents	Ratio/ Proportion
Pre-test						
Students of Color (n = 13)	38.31%	53.85%	47.69%	61.62%	40.38%	64.00%
White (n = 11)	48.36%	45.45%	49.09%	63.73%	45.45%	75.82%
Posttest						
Students of Color (n = 13)	73.08%	66.69%	87.79%	89.85%	77.00%	90.30%
White (n = 11)	86.36%	78.73%	87.27%	97.00%	69.73%	90.91%

Table 2: Test 1 Total Scores by Race

	Students of Color (n = 13)	White (n = 11)	Total (N = 24)	Difference
Pre-test	50.38%	52.73%	51.46%	2.35
Posttest	82.31%	85.45%	83.75%	3.14
Difference	31.93%	32.72%	32.29%	

Table 3: Breakdown of Sub-skills for Test 3 (Class Averages)

	Area	Perimeter	Volume	Geometric Terms	Add/ Subtract Measures	Multiply/ Divide Measures
Pre-test	0%	08.7%	0%	72.1%	68.1%	65.9%
Post test	43.5%	52.2%	100%	84.4%	79.0%	84.1%

Table 4: Breakdown of Sub-skills for Test 4 (Class Averages)

	Point/Slope and the Coordinate plane	Evaluating Expressions	Writing an equation given a scenario	Solving Word Problems	Solving Multi-step Equations
Pre-test	14.5%	82.4%	23.9%	32.6%	54.3%
Post test	43.9%	89.1%	38.4%	50%	98.9%

Figure 1

Students' Journal Comments: Teacher Feedback

Pedagogy

I like straightforward questions without context because I am ESL.

Do problems that coincide with the tests.

I would like to see the steps written out to solve the problems.

I would like a more detailed review of the test.

I enjoy group work.

Materials

The diagnostic tests were excellent tools.

I thought the computer work was fun.

I like hands-on and/or manipulatives.

Journal writing is a good tool.

Content

The butterfly method was helpful in understanding how to compare fractions.

The geometry test was hard.

Measurement problems are hard for me.

I am improving in probability.

I get the slope and y-intercept confused.

Environment

The classroom environment was supportive and non-threatening.

I felt comfortable in the class because it was okay to ask questions.

I am happy that I can use notes on the exams.

Figure 2

Student Journal Responses: Beliefs and Attitudes

Beliefs

I will do better in algebra than geometry.

The instructors of the course are knowledgeable and helpful.

A good teacher is able to help her students learn in a variety of ways.

This course will prepare me for mathematics methods.

I believe if I continue to practice, I will get the hang of it.

The professor cares about us.

Attitudes

I hate math!

I like algebra.

I like measurement.

Geometry is my favorite topic.

Math is hard because it makes you think how to solve, but once you get the concept it's easy.

I always hated fractions.

I like this class; it refreshes my memory, and I get a variety of ideas about how to teach math.

I hate word problems.

Math is my favorite subject.

I like math now because I can understand why instead of only following the rules.

I enjoy the challenges of the course.

I enjoy practice.

Figure 3

Student Journal Responses: Anxiety/Comfort

Anxiety/Comfort

I am apprehensive and nervous when it comes to math.

I am worried about my grade and/or GPA.

I am worried that I will not be a good teacher.

I do not know how to explain my reasoning behind solving a problem.

I feel confident about a test when I am well prepared.

I feel comfortable and/or confident about the content.

I am confident about the quizzes and/or tests.

I am happy with myself when my grades are good.

I am usually confused and nervous about math, but this is not the case in this class.

Appendix

Mathematics Teaching Readiness Exam and Answer Key

Summer 1999, Form B

MATHEMATICS TEACHING READINESS EXAM
Summer 1999, Form B

Name _____

ID NUMBER _____

Date, Time _____

This booklet contains 32 multiple choice questions. Try to answer all of the questions in the one hour allotted. Make no marks on the test booklet. You will be given a blank sheet of paper for scratch work. Please put your name on it and turn it in with the test booklet and answer sheet. Be sure to put your name, today's date and your ID number in the appropriate spaces on the answer sheet. For each multiple choice item, please mark your answer on the answer sheet by darkening the "bubble" for the letter of your chosen answer.

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1. What one number can replace the x in the following equation?

$$\frac{8}{x} = \frac{x}{12 \frac{1}{2}}$$

- a) $x = 100$ b) $x = 20.5$ c) $x = 10$ d) $x = 8$ e) $x = 1.56$

2. Which of the following is closest to $(.49012)(.49012)(.49012)$?

- a) 120 e) 12.0 c) 1.20 d) 0.120 e) 0.012

3. When any three different numbers from Set A are multiplied, what is the largest possible product?

$$\text{Set A} = \{-3, -2, -1, 2, 3\}$$

- a) 6 b) 12 c) 18 d) 24 e) 30

4. Order from largest to smallest: $9/20$, $1/2\%$, $7/50$, 2% , 0.2

- a) $7/50$, $9/20$, 0.2 , 2% , $1/2\%$

- b) 0.2 , $9/20$, $7/50$, 2% , $1/2$

- c) $9/20$, $1/2\%$, $7/50$, 2% , 0.2

- d) $7/50$, 0.2 , 2% , $1/2\%$, $9/20$

- e) $9/20$, 0.2 , $7/50$, 2% , $1/2\%$

5. Which of these numerical expressions is the largest?

- a) $13579 + 1/2468$ b) $13579 + 2468$

- c) $13579 - 1/2468$ d) $13579 \times 1/2468$

- e) 13579.2468

6. What number is halfway between $2 \frac{1}{4}$ and $3 \frac{3}{8}$?

- a) 2 and $7/8$ b) 2 and $13/16$ c) 2 and $3/4$ d) 5 and $5/8$ e) 3

7. You have 54 pounds of sugar. How many 8 pound bags can you fill?

- a) 5 b) 6 c) 6.75 d) 7 e) 8

8. 110% of 110 = _____.

- a) 0 b) 1 c) 11.0 d) 111 e) 121

9. Which of the following is the better buy?

- a) 25 pounds of potatoes at \$2.25
 b) 30 pounds of potatoes at \$2.95
 c) 20 pounds of potatoes at \$2.00
 d) 100 pounds of potatoes at \$8.50
 e) 75 pounds of potatoes at \$7.49

10. Which of the following is the largest?

- a) $\frac{0.1}{2}$ b) $\frac{1}{2}$ c) $\frac{0.1}{0.2}$ d) $\frac{0.2}{0.1}$ e) $\frac{1}{0.2}$

11. Which of the following is a positive whole number?

- a) $|(6+8)/2| + 9$ b) $(4 - (-17)) + (2 + 5)$ c) $1 + (16 - 9)$
 d) $1/2 - 1/3 + 1/6$ e) $\frac{12}{1/3 + 1/4}$

12. What is the price of a 9 ft. by 12 ft. piece of carpet if the carpet sells for \$18.00 per square yard?

- a) \$126 b) \$216 c) \$378 d) \$1,944 e) \$2,464

13. If $(2x - 1) + 2 = 5$, then $(2x + 1) =$ _____?

- a) 16 b) 15 c) 14 d) 13 e) 12

14. If a distance of 81 miles on a map is represented by 2 and $\frac{1}{4}$ inches, how many inches would be needed for a distance of 117 miles?

a) $1\frac{7}{16}$ inches b) $3\frac{1}{4}$ miles c) $3\frac{1}{4}$ inches
d) $7\frac{3}{4}$ inches e) $18\frac{1}{4}$ miles.

15. If $2x + 5 > 3$, which of the following must be true?

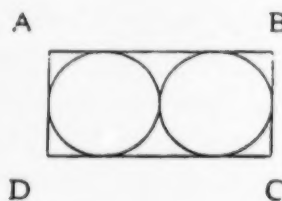
a) $x < -1$ b) $x > 4$ c) $x = -10$ d) $x > 1$ e) $x > -1$

16. If $x > 1$, and $\frac{x^n}{x^2} = x^3$ for all x , then $n =$ _____?

a) 1 b) 2 c) 5 d) 6 e) 7

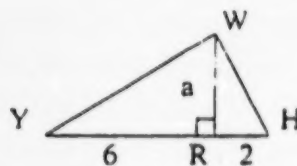
17. The sum of the areas of the congruent circles is 50π square inches. What is the area of rectangle ABCD in square inches?

a) 25π sq. in. b) 50 sq. in. c) 50π sq. in.
d) 200 sq. in. e) 288 sq. in.



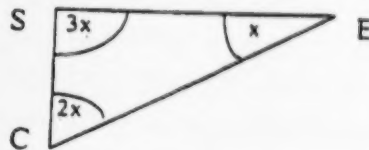
18. If the area of triangle WHY is 24 square units, then $a =$ _____?

a) 21 units b) 4 units c) 5 units
d) 6 units e) 12 units



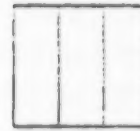
19. Find the angle measure for angle C.

a) 30° b) 36° c) 45°
d) 60° e) 90°



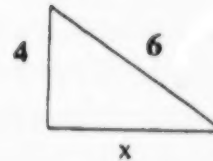
20. A square is divided into 3 congruent rectangles, as shown in the diagram. If the perimeter of one of the 3 rectangles equals 24 meters, how many meters are in the perimeter of the square?

a) 24 meters b) 36 meters c) 48 meters
d) 64 meters e) 72 meters



21. Find the measure of x in this right triangle.

a) 1 unit b) 2 units c) 5 units
d) $\sqrt{20}$ units e) $\sqrt{42}$ units



22. A number multiplied by 3 produces the answer 60. If you divide the same number by 3, the answer will be _____?

a) 3 b) $6\frac{2}{3}$ c) 20 d) 180 e) 540

23. If the average score on your first 5 math tests was 27, and your average for the first 6 tests was 28, then what was your score on the 6th test?

a) >28 b) $= 28$ c) < 28 d) none of these e) not enough information given

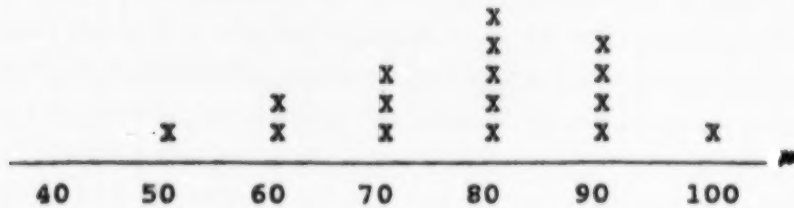
24. Which of the following is equal to 1?

a) $(-3) - (-2)$ b) $(-3) + (-2)$ c) $(-3) - (-3)$
d) $(-3) + (-3)$ e) $(-3) - (-4)$

25. If 50 miles is the same distance as 80 kilometers, and you traveled 120 kilometers, how many miles did you travel (to the nearest whole mile)?

a) 75 kilometers b) 75 miles c) 160 kilometers d) 160 miles e) 400 miles

For items 26. and 27., refer to the figure below. The diagram indicates scores that students received on a math test. The number of X's above each score represents how many students received that score.



26. Based on the diagram above, which of the following statements is/are true?

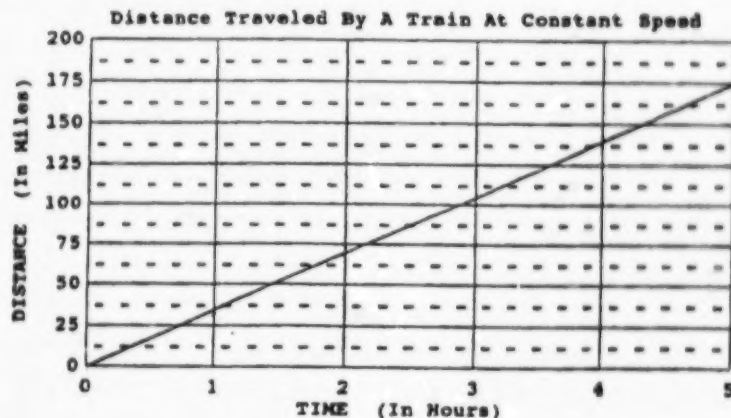
- a) The mode is the greatest value of all the scores.
- b) The mean is the least value of all the scores.
- c) The mode and median are equal.
- d) The mode and mean are equal.
- e) The mode, median and mean are equal.

27. Based on the diagram above, which of the following statements is/are true?

- a) The distribution is symmetric around the score of 80.
- b) The distribution is skewed toward the low end.
- c) The distribution is skewed toward the high end.
- d) The distribution appears to be normal.
- e) The mean of the distribution is 80.

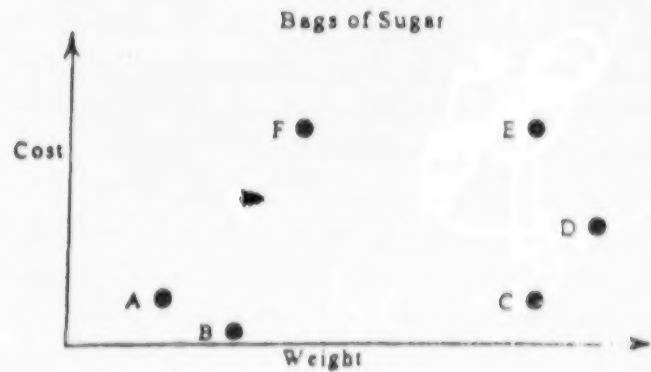
28. From the graph at right, what was the constant speed of the train during the time period shown?

- a) 35 mph b) 70 mph
- c) 105 mph d) 175 mph
- e) 200 mph



29. Refer to the figure at right.
Which bags have the same weight?

- a) E and F b) C and F
- c) A and C d) C and E
- e) No two bags have the same weight.



30. Refer to the figure at right. Which
of F or D gives the better value?

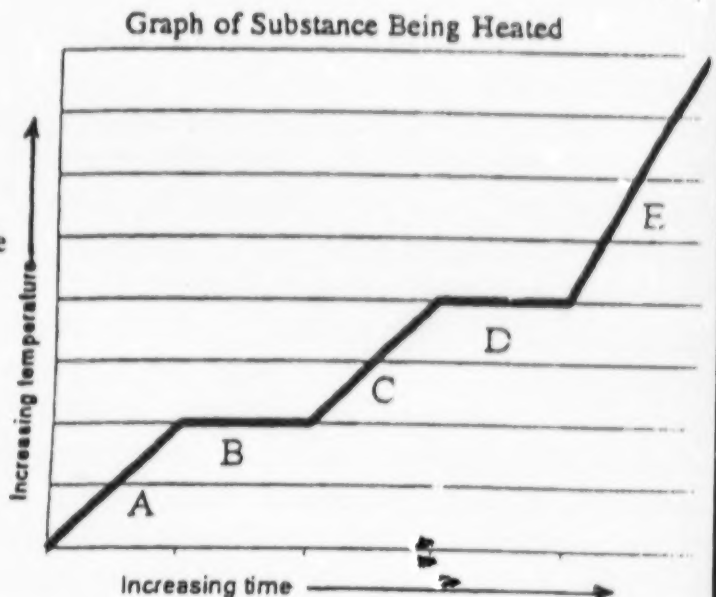
- a) D because it weighs more and costs less.
- b) F because it weighs more and costs less.
- c) D, because it weighs more.
- d) F, because it weighs more.
- e) They would give the same value.

31. Refer to the graph at right. Which statement
best describes the general trend of the graph?

- a) No general trend is identifiable.
- b) Temperature decreases with time.
- c) Temperature increases with time.
- d) Time causes temperature to increase.
- e) Temperature and time are unrelated.

32. Refer to the graph at right. What significance
do the plateaus (segments B and D) have?

- a) They have no significance interpretable from this graph.
- b) They represent times when the process stops working.
- c) They show that temperature and time are unrelated.
- d) They represent periods of time during which temperature remains constant.
- e) They show that you can't predict what the temperature will be for any given time.



You have finished the test.

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3	A	B	C	D	E	13	A	B	C	D	E
4	A	B	C	D	E	14	A	B	C	D	E
5	A	B	C	D	E	15	A	B	C	D	E
6	A	B	C	D	E	16	A	B	C	D	E
7	A	B	C	D	E	17	A	B	C	D	E
8	A	B	C	D	E	18	A	B	C	D	E
9	A	B	C	D	E	19	A	B	C	D	E
10	A	B	C	D	E	20	A	B	C	D	E
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24	A	B	C	D	E	34	A	B	C	D	E
25	A	B	C	D	E	35	A	B	C	D	E
26	A	B	C	D	E						
27	A	B	C	D	E						
28	A	B	C	D	E						
29	A	B	C	D	E						
30	A	B	C	D	E						

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